Sustainability and the waste hierarchy

A discussion paper on the waste management hierarchy and its relationship to sustainability

Product Stewardship Centre of Excellence

WHITE PAPER

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Helen Lewis and John Gertsakis

SUMMARY

In 2003 RMIT's Centre for Design prepared a discussion paper on the waste management hierarchy and its relationship to sustainability for the Victorian Government. As co-authors, we (Helen Lewis and John Gertsakis) believed that when executed comprehensively, the waste management hierarchy (the hierarchy) was a key concept in maximising product and resource productivity, dematerialising, designing out-waste and pollution, and conserving finite resources; principles and objectives typically associated with defining a circular economy today.

In this updated version of the paper, we reflect on how the hierarchy has been implemented since that time, and the existence of major gaps in the higher levels of the hierarchy. Most focus by government policy makers, grant schemes and industry players has been at the lower levels of the hierarchy, particularly recycling at end-of-life. There has been less progress achieved in promoting and implementing reduction, reuse, and other strategies at the top of the hierarchy.

We also explore the relevance of new frameworks such as the circular economy, and product stewardship which in many ways is not new but does help to refocus attention on strategies that reduce waste and extend the life of products and materials.

As a minimum we trust this paper triggers some reflection and scrutiny of the widening gap between systemic concepts and their implementation at scale by government and industry. Any discussion about the waste management hierarchy and its relationship to sustainability requires that we vigorously pursue what is ecologically responsible, socially meaningful, economically sound and culturally relevant.

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Preamble

Concepts evolve, new knowledge is created, our thinking expands, and fresh new buzzwords emerge, some with substance and many a reflection of the hype cycle in action. Depending on the sector or industry in question, new concepts and knowledge may provide a powerful force for change and a more sophisticated view of how we can produce and consume differently to reduce planetary impacts. And in other instances, they remain as relatively impotent ideas and approaches that fail to be applied at scale to address the environment impacts and challenges created by human activities.

Often attractive, compelling, and seemingly rational ideas, disillusionment presents when the challenge of implementation comes to the fore. This can be especially relevant when we talk about operationalising the waste management hierarchy (the hierarchy), sustainability, and more recently, circularity.

This paper does not set out to address the barriers to implementation, but to highlight how the passage of time serves to acknowledge the relatively slow rate of progress to prevent and reduce waste in Australia. It is just as much a comparative historical assessment as it is a discussion about the slow pace of reform and improvement that many actors commit to intellectually but underachieve when it comes to implementation at scale.

It is timely to explore and assess where we've been, where we are, and whether the destination is real or a utopian location that redefines itself every decade or so, informed by new data and scholarly research, government policies and strategies, industry advocacy and community expectations and demands.

If we look to recent history, what can we learn about headline concepts and terms that many of us work with daily or weekly? More importantly what can we conclude about the barriers to reform and improvement that stand in the way of creating a sustainable future that is circular and far less resource intensive?

In 2003, Ian Coles, then Chief Executive Officer of Victorian Government agency EcoRecycle Victoria, asked RMIT's Centre for Design to prepare a discussion paper on the waste management hierarchy and its relationship to sustainability. As co-authors, we (Helen Lewis and John Gertsakis) enthusiastically engaged with the exercise. We believed that when executed comprehensively, the hierarchy is a useful concept to promote maximising product and resource productivity, dematerialising, designing out-waste and pollution, and conserving finite resources; principles and objectives typically associated with product stewardship and defining a circular economy today.

What Australia has achieved in the lower half of the waste management hierarchy over the last two decades is important, and even noteworthy in some cases. However, it clearly has not been sufficient given our performance against the 2019 National Waste Policy Action Plan[1] and growing impacts associated with waste generation.

It could be argued that Australia is proficient in managing the symptoms of over-production and over-consumption, and thus the focus in the bottom half of the hierarchy, where most of the investment, grants and infrastructure announcements occur. Conversely, structural reform to achieve prevention, avoidance, product durability and repairability and regeneration is a very slow burn in Australia. It is typically avoided by policy-makers and regulators focused chiefly on post consumption and end-of-life solutions.

Although dominant in modern healthcare, the mantra of *prevention is better than cure* has yet to be enthusiastically embraced by policy-makers, regulators and grant-givers, apart from piecemeal funding of repair cafes, tool libraries and some reuse projects.

[1] https://www.dcceew.gov.au/environment/protection/waste/publications/national-waste-policy-action-plan

These are essential building blocks of waste prevention, but consistently underfunded or perceived as soft solutions best administered by volunteers, charities, and not-for-profits.

Within the context of discussing the hierarchy, sustainability, circularity and product stewardship, the challenge for all actors across product lifecycle is to embrace complexity and adopt *specific* circularity objectives that maximise product and resource productivity to deliver regenerative and restorative solutions, as opposed to managing the symptoms of unsustainable levels of consumption. While very challenging and difficult, Australia needs to focus on positive and often disruptive policies and strategies that can go beyond 'less bad' and less harm.

As a minimum we trust this paper triggers some reflection and scrutiny of the widening gap between concepts and their implementation at scale.

Any discussion about the waste management hierarchy and its relationship to sustainability, circularity and product stewardship requires that we vigorously pursue what is ecologically responsible, socially meaningful, economically sound and culturally desirable.

Introduction

The waste management hierarchy is a concept that promotes waste avoidance ahead of recycling and disposal. The shortened version of the hierarchy, 'reduce reuse recycle' is frequently used in community education campaigns and has become a well-recognised slogan for waste reduction and resource recovery.

The purpose of this paper is to review the continuing relevance of the waste management hierarchy as a guiding principle, particularly in the context of:

- Sustainability goals, which need to consider complex relationships between impacts (such as waste and energy) and between systems (physical, social and economic systems) rather than focusing on single issues
- The development of new technologies for waste recovery, such as gasification, energy from waste and commercial composting
- New concepts and trends in product-oriented policy, including product stewardship, lifecycle assessment, eco-innovation, eco-efficiency and the circular economy

This paper also discusses the following issues:

- Is there a practical definition of sustainability or a set of principles that can be used to guide decision-making on waste reduction and resource recovery?
- How is the concept of a waste hierarchy currently being used to guide decision making on waste reduction and resource recovery?
- Does the waste hierarchy need to be redefined in the light of current thinking on sustainability and the circular economy?
- How can the waste management hierarchy be used to promote more sustainable systems of production and consumption?

The theme of the paper is *sustainability* and how the waste management hierarchy could be reinterpreted or re- applied in a more focused way to deliver positive socio-environmental outcomes that are preventative in nature.

Significant change within a relatively short timeframe is essential if we are to achieve a sustainable future. This means that society can no longer continue with the 'incremental change' approach. There is potential for a more sophisticated role for the hierarchy as a way of shifting to more sustainable systems of production and consumption.

Defining Sustainability

Sustainability has been defined as the goal of sustainable development, which is 'types of economic and social development that protect and enhance the natural environment and social equity' (Deisendorf, 2000, p. 23).

The term 'sustainable development' entered the public debate after the World Commission on Environment and Development published their landmark report, *Our Common Future*, in 1987. It was defined in this report as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, p. 43). *Our Common Future* identified a series of social and ecological challenges that required a global response, including unsustainable patterns of industrial development. It recommended that:

In general, industries and industrial operations should be encouraged that are more efficient in terms of resource use, that generate less pollution and waste, that are based on the use of renewable rather than non-renewable resources, and that minimize irreversible adverse impacts on human health and the environment (WCED 1987: 213).

Many writers and policy makers since then have attempted to further define sustainability and to develop practical strategies. This paper is not intended to be an exhaustive overview of the literature, however some of the key ideas are discussed below.

In *Beyond the Limits,* Meadows *et al* (1992) defined a sustainable society as 'one that can persist over generations, one that is far-seeing enough, flexible enough and wise enough not to undermine either its physical or its social systems of support' (p. 209). The authors note that social sustainability requires that living standards are adequate and secure for everyone. To be physically sustainable, society's material and energy throughputs need to meet three conditions:

- Its rates of use of renewable resources do not exceed their rates of regeneration
- Its rates of use of non-renewable resources do not exceed the rate at which sustainable renewable substitutes are developed
- Its rates of pollution emission do not exceed the assimilative capacity of the environment (Herman Daly, cited in Meadows et al 1992: 209).

Other writers have highlighted the fact that 'true' sustainability will require significant increases in the efficiency of resource use (often called 'eco-efficiency'). Von Weizsacker et al (1997) present compelling evidence that a factor four reduction in resource use is both necessary and achievable with technologies that already exist. The Dutch Government estimated that the required improvement in eco-efficiency is at least 20. It also demonstrated that this was possible using future visions to derive the research and development agenda of today (Vollenbroek, 2002, p. 216). Hall (2002, p. 195) argued that while the introduction of innovation is never straightforward, 'sustainable development innovation' is even more complex because it faces resistance from a broad range of stakeholders. It involves consideration of 'not only technological and environmental considerations, but also the dynamics of social change'.

John Elkington introduced the term 'triple bottom line sustainability' in his book *Cannibals with Forks* (1998). Elkington argued that businesses need to address the triple bottom line - economic prosperity, environmental quality, and social justice. The principle and language of triple bottom line sustainability have been adopted by many governments and corporations. The Victorian Government, for example, introduced a series of principles into the Environment Protection Act that are designed to provide a framework for administration of the legislation. These principles include the fact that sound environmental practices 'should require the effective integration of economic, social and environmental considerations in decision-making processes with the aim to improve community well-being and the benefit of future generations.'

One of the most fundamental conclusions about sustainability is that our current patterns of production and consumption are unsustainable. Hardin Tibbs has described what he sees as 'the crisis of unsustainability', and notes that there will need to be a transitional period while current patterns of unsustainability are replaced by a future condition of sustainability (Tibbs, 1999).

In their book *Natural Capitalism,* Paul Hawken, Amory Lovins and Hunter Lovins argued that the earth's natural capital, in the form of products such as timber and oil, and services such as water storage and clean air, is diminishing at an alarming rate:

Humankind has inherited a 3.8-billion-year storage of natural capital. At present rates of use and degradation, there will be little left by the end of the next century. This is not only a matter of aesthetics and morality; it is of the utmost practical concern to society and all people. Despite reams of press about the state of the environment and rafts of laws attempting to prevent further loss, the stock of natural capital is plummeting and the vital life-giving services that flow from it are critical to our prosperity. (Hawken *et al* 1999: 3)

Donella Meadows and her co-authors of *Beyond the Limits* supported this view. They argued that human consumption of many essential resources and generation of many pollutants have already surpassed rates that are physically sustainable, and that we need to drastically increase the efficiency with which we use materials and energy (Meadows, Meadows, & Randers, 1992, pp. xv - xvi).

Meadows *et al* regarded recycling as an essential tool in achieving sustainability:

Separating and recycling materials after use is a step toward sustainability. It begins to move materials through the human economy the way they move through nature - in cycles. In nature the waste from one process becomes an input to another process. Whole sectors of ecosystems, particularly in the soils, work to take nature's waste materials apart, separate them into usable pieces, and send them back into living creatures again. The modern human economy is finally developing a recycling sector too. (82-83)

The authors of *Natural Capitalism* (Hawken et al, 1999) argued that we need a new industrial revolution; one that moves us to a new industrial system that values human and natural capital as well as conventional economic values. They proposed four strategies for natural capitalism:

- Radical resource productivity –using resources more efficiently
- Biomimicry - eliminating waste through closed cycles and elimination of toxicity
- Service and flow economy – a shift from an economy based on products to one based on services
- Investing in natural capital – reversing environmental destruction through investment in sustaining and restoring natural capital (pp. 10-11).

At a policy level, the European Commission (EC) has consistently presented a relatively strong view about the critical importance of sustainable development and the implications for Europe and beyond. While the Commission's thinking on sustainability is consistent with the Brundtland definition, the focus in one of their policy documents was on how the concept could be transformed into an operational reality:

Sustainable development must be placed at the core of the mandate of all policy makers. Better policy integration, relying on systematic and transparent review of the costs and effects of different options, is crucial, so that different policies reinforce each other, trade-offs are made by informed decisions, and environmental and social objectives are met at least economic costs. Openness will also facilitate better dialogue between stakeholders with divergent interests, paving the way for a broad consensus on solutions and their implementation. (European Commission, 2001, p. 3)

Another key issue raised by the Commission was the connection between production and consumption within the context of sustainable development. The paper stresses the growing momentum behind initiatives concerned with greater consumer education, and the cultural change necessary to fully exploit the sustainability potential of smart technologies (European Commission 2001:3).

'Responsible consumption and production' is gaining increasing attention as one of the 17 Sustainable Development Goals (SDGs). The SDGs form part of the *2030 Agenda for Sustainable Development*, which was adopted by all United Nations Member States in 2015[2]. The SDGs provide a practical framework that many governments and other organisations are now using to integrate sustainability into their policies and practices.

What is consistent across much of the literature on sustainability is the notion of a dynamic concept that is evolving as new knowledge is developed. The broadness and all-encompassing nature of sustainability demands a high degree of flexibility that can process and operationalise new data and information across multiple sectors, disciplines, and geographies.

In summary:

- Our current rates of resource consumption and pollution are unsustainable because they exceed the rates at which resources can be regenerated and wastes assimilated by the Earth's natural systems. Society is depleting its stocks of natural capital at an unsustainable rate.
- Sustainability requires radical new ways of thinking to achieve significant changes in production and consumption systems. This includes a more sophisticated understanding of complex interactions between different environmental impacts and looking for step change innovation rather than incremental change.
- Sustainability must address social issues such as access, equity, and justice along with economic and environmental sustainability i.e. the new triple bottom line for business and government.
- Key strategies for sustainability include radical improvements in eco-efficiency, the closing of material and waste cycles (eliminating waste) and a shift from products to services i.e. dematerialisation.

[2] https://www.legislation.vic.gov.au/repealed-revoked/acts/environment-protection-act-1970/216

Sustainability and the circular economy

The specific principles often associated with a circular economy are not necessarily new, evidenced for example by the work of Swiss architect Walter Stahel and the Product Life Institute in the 1980s. He pioneered the concept of the Performance Economy and the sustainability benefits of maximising resource productivity through durability, product life extension, reuse, repair, refurbishment and dematerialisation, as well as product-service strategies and alternative business models. (Product Life Institute, 2024)

Today, the concept of a 'circular economy' is exceptionally well promoted by diverse actors and increasingly being adopted as a new framework for sustainable development. The Ellen Macarthur Foundation (EMF) has promoted and helped to popularise the concept over the past decade, defining it as:

> *… a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources. (EMF, 2024)*

In December 2015 the European Commission adopted a comprehensive and ambitious *Action Plan for the Circular Economy* that aims to transform the economy:

> *The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such a transition is the opportunity to transform our economy and generate new and sustainable competitive advantages for Europe. (European Commission, 2015, p. 214)*

The Action Plan takes a lifecycle approach, with measures to promote ecodesign, reduced impacts in production, and less waste at end of life. Legislative proposals included the development of general operating requirements for Extended Producer Responsibility (EPR) schemes as well as ambitious reduction, reuse, and recycling targets.

The European Commission is not alone in its focus on economic drivers for materials efficiency and recycling. The Japanese Government has stated that its EPR laws are designed to create a sustainable economic system based on the '3Rs' (reduce, reuse, recycle) (Ministry of Economy, 2008). There is increasing recognition within China that the government's development targets will not be met without significant improvements in material efficiency (Lowe, 2009). The Chinese Government's Circular Economy Law, which is designed to support the 'economic and social development of the state', places obligations on government agencies, producers and consumers, including reuse and recycling.

Business leaders also recognise that material efficiency and resource recovery are essential for future economic development. The US Chamber of Commerce Foundation has published an edited series of papers that outline the rationale for a circular economy and new business (US Chamber of Commerce, 2015). The Foundation's Jennifer Gerholdt argues that the linear economy, in which resources are extracted, transformed, used and thrown away, is no longer sustainable. Continuing with a 'business-as-usual' approach will lead to increasing commodity prices and price volatility and a decline or depletion of critical material inputs. The 'good news', according to Gerholdt, is that companies are actively pursuing alternative approaches that support a more circular economy (p. 4).

Five ‘circular business models’ that provide benefits for individual businesses and the broader economy have been proposed by consulting group Accenture:

- a circular supply chain, in which scarce or environmentally destructive resources are replaced by renewable, recyclable or biodegradable materials that can be used in consecutive life cycles to reduce costs and increase predictability and control
- the recovery and recycling model that eliminates waste—everything that used to be considered a waste is recovered for another purpose
- the product life extension model, in which the lifespan of a product is extended as long as possible through design for durability, repair, upgrades, remanufacturing or remarketing to capture value that would otherwise be lost
- the sharing platform model that allows consumers to make and save money by renting, sharing, swapping or lending under-utilised products

the ‘product as a service’ model, in which producers and retailers lease rather than sell products and have an incentive to improve longevity, reliability and reusability. (Lacy & Rutquist, 2015)

While the circular economy may be viewed as an aspirational goal rather than an end point, there are several efforts underway to try to measure and report on progress, either within countries, regions or companies (Talwar, Lewis, & Retamal, 2022). These include:

The Circularity Gap Reporting Initiative (CGR[3]), which delivers an annual global Circularity Gap Report that measures the state of the world economy and identifies key levers to transition to global circularity. Circularity Gap Reports are also being produced for countries and regions.

Circular Transition Indicators developed by the World Business Council for Sustainable Development for use by individual companies[4].

The role of product stewardship and extended producer responsibility

Product stewardship provides an essential and practical pathway towards a circular economy. This is the principle that every organisation involved in designing, manufacturing, and selling products should accept responsibility for any adverse impacts on the health of humans and environments and take steps to reduce impacts across the whole lifecycle (Florin, Talwar, & Read, 2023).

Product stewardship is a more holistic concept than extended producer responsibility (EPR), which generally refers to government regulations that make producers physically or financially responsible for the collection and recycling of products at end-of-life. In contrast, product stewardship requires producers to be responsible for and take action to prevent products from creating harm to the environment and human health over the entire product lifecycle, including end-of-life. It seeks to operationalise producer responsibility across the entire product lifecycle from design and production through to consumption and post-consumption.

[3] https://www.circularity-gap.world/about

[4] https://www.wbcsd.org/Programs/Circular-Economy/Metrics-Measurement/Circular-transition-indicators

Product stewardship squarely places responsibility and accountability for environmental performance and impact reduction across the entire product lifecycle on producers and brands. It is not a diluted notion of shared roles, which often fails to delineate who owns the impacts, be they solid and hazardous wastes at end of life, greenhouse gas emissions, or the specification of unsafe chemicals, finite resources or non-renewable inputs at the design and production stage.

Most collective product stewardship schemes in Australia have been established to manage impacts at end-of-life by providing a collection and recycling service. An evaluation of over 100 product stewardship schemes in Australia found that only a third of schemes were taking action across all three stages of the lifecycle, i.e. production, consumption and post-consumption, with most focusing on take back and recycling (Florin, et al., Environmental, social and economic benefits of product stewardship initiatives in Australia, 2023). The report recommended a greater focus by product stewardship schemes on activities at the design, production and consumption lifecycle stages to avoid waste generation. (Florin, et al., 2023)

In summary:

- The concept of a circular economy builds on earlier research and policy development in sustainability and sustainable development.
- The concept provides a valuable contribution by promoting the importance of reducing consumption and keeping materials and products circulating at their highest value for as long as possible.
- The circular economy also adds value by highlighting links between material flows and sustainability impacts such as climate change and biodiversity loss.
- Product stewardship can drive more sustainable production and consumption systems, but it must focus on the full product lifecycle rather than solely end-of-life.
- Product stewardship provides a clear pathway for businesses to operationalise circular economy and environmental, social and governance objectives to design out waste and pollution from the outset.

Merging circularity and the waste management hierarchy

The original waste management hierarchy can be traced back to the 1970s, when many organisations in the environment movement started to critique the practice of disposal-based waste management. Rather than regarding 'rubbish' as a homogenous mass that should be buried, they argued that it was made up of different materials that should be treated differently – some shouldn't be produced, some should be reused, some recycled or composted, some should be burnt, and others buried (Schall, 1992).

As a concept or principle, the waste management hierarchy makes sense in a way that is difficult to oppose. It echoes approaches that are widespread in human health and medicine, i.e. prevention is better than cure. Most would agree that it is more effective to avoid problems from the outset, than to invest in reactive solutions once the problem has been presented. The parallels in human health and environmental protection are similar and supported by considerable scientific evidence and knowledge. Within the context of industrial environmental management in the 1980s and 1990s, end- of-pipe responses were increasingly viewed as ineffective in their long-term impact.

Cleaner Production represents one approach that helped inform the development of the hierarchy. Together with Cleaner Production, there emerged other related terms and concepts such as source reduction and P2 or Pollution Prevention – the American equivalent of Cleaner Production. The essence of these approaches is characterised by a need to avoid, eliminate, prevent or significantly reduce the causes of environmental problems, as opposed to managing the impacts, wastes and emissions arising further down the product or service lifecycle. This suggests a fundamental change in the nature of environmental interventions in terms of rationale, timing and specific approach.

Although terminology can vary, a simple description of environmental attributes and outcomes of the waste management hierarchy is outlined in Table 1.

Table 1:Attributes of the original waste hierarchy

Goal	Attribute*	Outcomes
Reduce	Preventative	Most desirable
Reuse	Predominantly ameliorative, part preventative	
Recycle	Predominantly ameliorative, part preventative	
Treatment	Predominantly assimilative, partially ameliorative	
Disposal	Assimilative	Least desirable

* Whereas a *preventative* approach seeks to eliminate or avoid the waste from the outset, an *ameliorative* process can only ever minimise or shrink the problem. Finally, an *assimilative* mode is underpinned by the view that the wider ecosystem can continue absorbing and integrating the waste into a larger system.

In Victoria, this waste management hierarchy is embedded in the Victorian Environment Protection Act[5], specifically stating that wastes should be managed in accordance with the following order of preference: avoidance, re-use, re-cycling, recovery of energy, treatment, containment, and disposal.

[5]https://www.legislation.vic.gov.au/repealed-revoked/acts/environment-protection-act-1970/216

Hirschhorn, Jackson and Baas (1993) provided a concise description of the transition in thinking from end-of-pipe to more preventative models and the more positive and affirmative role that precautionary strategies can achieve:

> *A multitude of terms and phrases define and describe the emerging preventative environmental paradigm. These terms include pollution prevention, source reduction, and waste reduction. Waste minimisation, toxics use reduction, and clean or cleaner technology. In theory, the newer sets of terms refer to forms of preventative action that shrink the fundamental causes of environmental problems. Certainly, the newer terms are becoming increasingly more popular than the more traditional phraseology of environmental protection such as pollution control, waste management, environmental control and waste disposal. These older actions are characterised by their attempt to solve environmental problems by reacting to the effects of pollutants. (1993: 125-143)*

While Hirschorn *et al* acknowledged the more radical commercial and industrial implications of avoidance and prevention, they also note the need for substantial changes in how products, services and associated materials are consumed:

> *Secondly, it is necessary to see the importance of addressing materials. Technology application and the production of goods and services depends on using materials. The roots of all pollution ultimately devolve to decisions on what raw materials to extract and use and what synthetic or engineered materials are manufactured to make, transport, and package products. The problems of wastes and pollutants are directly related to the materials cycle. Hence, implementation of the prevention paradigm can be through changes in the materials cycle and, therefore, it is no surprise that environmentalists have increasingly focused on toxics-use reduction. (1993: 136).*

Hirschhorn *et al* also demonstrated a high degree of realism and recognised that a hierarchy of prevention necessarily requires upheaval and organisational change that is not always desirable or appealing to companies that have invested heavily in conventional environmental management systems and other end-of-pipe strategies.

A more detailed waste management hierarchy has been developed in recent years, reflecting an increasing focus on prevention and reuse (Table 2). Commonly referred to as the '9Rs', this framework aligns with new thinking about the circular economy. Strategies at the higher levels of the hierarchy require greater innovation in core technology, product design, revenue model and socio-institutional change (Potting, Heckert, Worrell, & Hanemaaijer, 2017).

Table 2: Circularity strategies within the production chain, in order of priority

Strategies	Attribute	Description
Smarter product use and manufacture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1 Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)
	R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials

Extend lifespan pf product and its parts	R3 Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
	R4 Repair	Repair and maintenance of defective product so that it can be used with its original function
	R5 Refurbish	Restore an old product and bring it up to date
	R6 Remanufacture	Use parts of discarded product in a new product with the same function
	R7 Repurpose	Use discarded product or its parts in a new product with a different function
Useful application of materials	R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	R9 Recover	Incineration of materials with energy recovery

Source: Potting, Heckert, Worrell, & Hanemaaijer (2017, p. 5)

It would be accurate to conclude that the waste management hierarchy is an important element guiding the formulation of waste related policies, regulations, programs, procurement and investment in Australia and overseas. It should also be noted however, that there are two schools of thought on the waste management hierarchy and how it should be interpreted within an integrated waste management framework:

One interpretation is that integrated waste management is a 'menu of options' and there is no such thing as a good or bad technology option. Each is equally valid depending on the circumstances

The other interpretation is that the hierarchy should be strictly followed, i.e. we should maximise the amount of waste prevented at source, then maximise the amount recycled or composted, and only then burn or bury the rest (Schall 1992).

In Australia, overall implementation of the hierarchy has been variable and piecemeal, with most effort and investment to date focused on recycling and composting. The degree to which Australian producers, brands and retailers of goods and services have engaged with upper levels of the hierarchy is relatively limited and in niche applications.

Preventative programs centered on waste avoidance are piecemeal and at best tinkering with minor efficiency gains rather than wholesale reconfiguration. Similarly, there is little evidence of widespread reuse, refurbishment or remanufacturing activity that can be classed as anything other than cottage-based or boutique in its orientation. Even though there are noteworthy Australian examples of remanufacturing such as Fuji Xerox (Benn, Dunphy, & Angus-Leppan, 2011), the reality is that national initiatives are limited. Such case studies are insufficient to demonstrate the success of public policies directed at achieving higher levels of waste avoidance and reduction.

A major barrier to implementation of the hierarchy is the fact that solid waste managers have very little control over the generation of waste and therefore have limited capacity to achieve source reduction. It could also be argued that upper-level hierarchy objectives associated with prevention, avoidance, durability, reuse and repair are potentially disruptive to many existing business models that depend on ameliorative measures that treat symptoms of over-production and over-consumption. For example, e-waste recycling businesses could see a growth in electronics repair businesses as a handbrake on securing feedstock for materials recovery (as opposed to repair, upgrading and product life extension).

Designers, engineers and managers in industry make decisions about what is manufactured, processed or constructed, and how this is done, and therefore the amount and type of waste generated. To be effective therefore, the waste hierarchy needs to be tackled by working in two different systems – the waste management system and the production system (Schall 1992).

The momentum internationally and locally is building around the goal of resource-use efficiency and the notion of doing more with less i.e. eco-efficiency. A key driver behind these approaches is the need to decouple economic growth from negative environmental impacts. Underpinned by life cycle assessment methodologies using quality data, the goal of resource-use efficiency has the potential to be well served by the hierarchy, especially if the emphasis within the hierarchy can shift upwards towards waste prevention and reduction.

The next section examines links between the waste management hierarchy and sustainability in more detail.

In summary:

- The waste management hierarchy is extensively used by governments, industry, educators and environment groups as a guiding principle for waste policy and programs.
- Interpretations of the hierarchy vary, with some governments and NGOs interpreting it strictly as a 'most preferred to least preferred' hierarchy, while others in government and industry would prefer an integrated approach that includes a range of waste management options without a constraining hierarchy definition.
- A barrier to implementation of the hierarchy is that solid waste managers in government and industry have little control over production decisions that influence waste generation, particularly in the absence of regulation.
- The level of policy and program implementation, regulatory intervention, procurement, investment and grants across the hierarchy does not reflect a rational view of the comparative benefits of prevention versus amelioration or symptom management.
- There is increasing recognition internationally of the need to focus more intensively on preventative strategies rather than waste reduction or recovery. Most of the current effort is still on recycling programs, which are important but not as effective as prevention or reduction strategies in achieving sustainability.
- The '9Rs' hierarchy provides a more useful guide to environmentally effective circularity strategies than earlier versions.

Waste and Sustainability

'Waste' includes both products that have reached the end of their useful life and by- products of other processes such as manufacturing, commerce, construction and demolition. The waste we see at the end of a product's life is only the tip of the iceberg. The actual waste generated at that point is a fraction of the materials used to process and transport the product throughout its life cycle. For example, a gold ring weighing 10 grams has generated approximately 3 tonnes of waste on a life cycle basis (von Weizsacker at al 1997: 242). This is sometimes called the 'ecological rucksack' or the 'ecological footprint' of a product.

The other important issue is that every product 'embodies' all the impacts that have already occurred throughout its life cycle, for example:

- The impacts of mining or harvesting raw materials – e.g. land degradation, emissions
- The impacts of manufacturing – e.g. use of materials and energy, air and water emissions, solid wastes
- The impacts of transporting raw materials and products to end markets

Waste management itself also has environmental impacts, such as the air emissions from garbage and recycling trucks collecting waste, and the water used in reprocessing. It can also have positive and negative social and economic impacts. Examples of each of these are provided in the Appendix.

Any consideration of a 'waste management hierarchy' therefore needs to consider the impacts of each waste management option, as well as any avoided impacts throughout the life cycle, for example from substituting recycled material for virgin material.

The key sustainability principles that need to be applied to waste management can be taken from *Natural Capitalism*, i.e. radical improvements in resource productivity and biomimicry, or elimination of waste through closed cycles.

As mentioned earlier many writers and policy makers have highlighted resource use efficiency as an essential step in achieving sustainability. Different conclusions have been reached about the required improvement in resource efficiency, ranging from a factor four improvement (75% reduction) to a factor twenty improvement (a ninety-five percent reduction). Related but also featuring its own attributes, 'biomimicry' refers to lessons that can be learnt from nature, in this case the fact that in nature nothing is wasted. The waste from one process becomes raw material for another in continuous closed cycles. In human terms this can be achieved through recycling and composting. If the hierarchy is to be logically and coherently linked to achieving sustainability, then a reinterpretation is necessary.

In its most simple form, there needs to be an organisational and technical shift that moves from a hierarchy dominated by resource recovery to a hierarchy of prevention or avoidance. This is not radical or academic. Indeed, it mirrors industrial environmental management thinking of the 1980s and 1990s whereby end-of-pipe responses were viewed as futile in favour of upstream solutions characterised by source reduction and cleaner production.

Implementation of the waste management hierarchy needs to consider several key principles:

- Avoidance and reduction should always be the preferred options because they avoid impacts across the entire product life cycle, including disposal. In sustainability terms they enable us to 'do more with less' and radically improve resource use efficiency.
- Recovery options should aim to preserve the maximum amount of embodied environmental value possible. In sustainability terms we should aim to eliminate waste through closed cycles that maximise the value of materials (in both environmental and economic terms) at all times.
- Energy recovery should only be used for materials that have no higher end use than to be converted to energy.

- Selection of recovery options should consider the broader sustainability impacts of each technology, not just their impacts on waste. Other environmental impacts may include greenhouse gas generation, water consumption and waterborne wastes. Social and economic impacts also need to be considered.

The second principle on maximising environmental value is supported by a life cycle assessment of packaging and paper waste, which found that most of the environmental benefit of recycling derived from the replacement of virgin material with recycled material management (Grant, James, Lundie, & Sonneveld, 2001). The implication is that closed loop recycling is the most likely to achieve environmental benefits, rather than 'downcycling' into lower value products.

Ultimately it seems that barriers to an effective hierarchy have less to do with suitable technologies and industrial capabilities, compared to the identification of corporate and institutional barriers. For the hierarchy to operate successfully demands attention across all levels and not just those that appear 'easy' or commercially relevant over the short term.

As outlined in section 3, one of the key barriers to implementation of the hierarchy is the need to influence decisions made by different actors in the economic system:

Governments and the waste management industry make decisions about the use of specific waste management technologies

Designers and managers in manufacturing and construction industries make decisions that influence the generation of waste

In summary:

- The literature on sustainability and circular economy supports the continuing relevance of the waste hierarchy as a guiding principle.
- However, any interpretation of the waste hierarchy must also consider broader environmental, social and economic impacts.
- Strategies for prevention and reduction are more challenging to current patterns of consumption and production, but ultimately more effective in shifting to sustainability.

The following case study of clothes washing may help to illustrate the benefits of using the waste hierarchy in a sustainability framework to guide decision-making.

Case study in sustainability thinking – sustainable clothes washing

The conventional recovery system for clothes washing machines in Australia is shredding to recover the metal content, and disposal of the remaining material ('shredder fluff').

A conventional interpretation of the waste hierarchy would lead to the following strategies being considered:

- Can we eliminate unnecessary components or reduce the weight of components i.e. can we maximise strength and/or performance to weight ratios **(Reduce)**
- Can we design components and the overall appliance to extend product life by avoiding faults, breakdowns and other problems that may result in premature disposal? **(Reduce)**
- Can we design for remanufacture so that components from old machines can enjoy a second life in another appliance? **(Reuse)**
- Can we design for recycling and incorporate recycled and recyclable materials? **(Recycle)**
- Can we design for disassembly and recyclability to recover materials from obsolete appliances? **(Recycle)**
- Can we establish take-back, disassembly and recycling programs for obsolete appliances? **(Recycle)**

A sustainability framework opens new opportunities for step change innovation rather than incremental improvement. The focus would shift to eco-efficiency and innovation. For example:

- Do we really need washing machines, or just a way of keeping clothes clean? We could consider alternative fibres that don't need washing **(Avoidance)**
- Can we develop a completely new technology for cleaning clothes that has a much lower environmental impact, such as microwave cleaning? **(Reduction)**
- Can we shift from a product to a service? For example, the manufacturer could lease machines to consumers and charge per wash or provide a low-cost pick-up washing service. **(Reduction)**
- Can we design machines for more effective remanufacturing, and establish lease and take-back systems like those currently in place for office equipment? **(Reuse)**
- Can we establish product stewardship programs that establish closed loop programs and eliminate waste from washing machines? **(Recycle)**
- Can we eliminate or significantly minimise environmental impacts from energy, water and detergent consumption? **(Avoidance and Reduction)**

Under a sustainability framework, system-wide impacts would need to be considered. For example, would a clothes-washing service reduce the impacts of the washing process by using larger and more efficient machines that operate continuously, but add to energy consumption and greenhouse emissions because of the transport used to collect clothes? Would the leasing option provide consumers with the latest energy and water-efficient technology, but be too expensive for low-income consumers?

At a policy level, this approach could be facilitated through programs that encourage change at key stages, including:

- product and/or system design
- production
- distribution
- use or consumption
- post-consumption and waste management

In many ways it is about processes that connect social and cultural factors with technical and economic imperatives. The aim is to focus on the function or service as a vehicle for achieving sustainability, rather than locking-in on the eco-redesign of a conventional product. Returning to basic principles as a means of stimulating sustainable innovations is fundamental.

Concluding remarks

A waste management hierarchy, whose levels operate in isolation of each other, serves to undermine the concept itself. Inherent in the waste management hierarchy levels is that they are linked by way of preference and benefit, thus the importance of viewing the entire concept as a model for maximising resource productivity and reducing impacts associated with production and consumption.

A potential solution involves initiatives and tools that are explicitly waste management hierarchy driven yet customised according to a specific product and its use, industry, sector, or geographic location. This would then require detailed development of actions and associated metrics to ensure broader sustainability goals are achieved. Tools that can cut through the rhetoric of environmental jargon and the hype of the latest concept are vital in delivering real world outcomes that are quantifiable.

This transition is complex and will require systemic change and design led thinking. At an international level, research, debate and policy development processes are striving to engage with the shift from waste management to resource efficiency, however, this phase clearly presents a major test to the fundamental nature of how society functions. A significant issue is how the concept of sustainability and frameworks like the waste management hierarchy and product stewardship can be developed into business actions and government regulations, procurement and programs that are effective across industries, sectors, disciplines, communities and professions.

Strategic thinking and creative action ought to become a mainstream approach across all industries and sectors. Genuine stakeholder engagement and involvement in policy formulation and implementation, underpinned by good science and enhanced with effective communication and education, represents an essential part of an evolving solution.

Circular economy, zero waste targets, dematerialisation, lifecycle thinking, ecological footprint analysis, sustainable consumption, sustainable design, product stewardship, these tools and approaches are potentially transformative if harnessed in a coherent manner. In isolation however, as they are typically applied in Australia, their overall potency is limited, underdeveloped and sometimes misunderstood. Thus, strategic policy formulation and the resulting on-ground programs are critically important.

A strong targeted approach is required that is consistent with the essence of circularity, sustainability and comprehensive product stewardship i.e. systemic thinking and redesign. Without it, a piecemeal and siloed approach will persist in gradualism and a failure to realistically reduce planetary impacts in a timely manner.

Government agencies at all three levels in Australia have a pivotal role to play in advancing the waste management hierarchy as the most effective model by which resource use efficiency can be maximised without constraining responsible economic development. This necessarily requires a stronger and more systematic focus on implementing and communicating the waste management hierarchy, especially initiatives centered on waste avoidance and reduction.

The knowledge and capabilities are certainly resident in Australia; a key challenge is creating a vehicle to mainstream the goal of sustainability. When this broader framework is in place and inclusive, then sub-themes like effective application of the hierarchy will flow in a more integrated and productive way. Alternatively, the risk of over-investing in recycling and not waste prevention, repair and reuse will result in applying yesterday's solutions to a future in desperate need of progressive ideas, actions, and leadership.

Sluggish and sometimes disinterested policy-making constantly citing 'biggest bang for buck' tends to serve economic objectives rather than environmental protection and sustainable resource use. Of course, cost effective solutions are essential but one could argue that commercial considerations often transcend environmental priorities.

It goes without saying that system design and design-led thinking is core to the structural reform process. By taking a systemic approach we start to adjust our thinking and action, and this requires much more than a league-ladder of desirable objectives. A transdisciplinary approach that takes collaboration and codesign seriously is just as important as the various technically oriented principles associated with achieving a sustainable future or a circular economy.

References

Deisendorf, M. (2000). Sustainability and sustainable development. In D. Dunphy, J. Benveniste, A. Griffiths, & P. Sutton, *Sustainability: the corporate challenge of the 21st century* (pp. 28-35). Sydney: Allen & Unwin.

Elkington, J. (1998). *Cannibals with forks: the triple bottom line of the 21st century.* Gabriola Island, BC: New Society Publishers.

EMF. (2024, April). *What is the Circular Economy?* Retrieved from Ellen Macarthur Foundation: https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

European Commission. (2001). *Consultation paper for the preparation of a European Union strategy for sustainable development.* Brussels: European Commission Sustainable Development Taskforce.

European Commission. (2015). *Towards a Circular Economy: A Zero Waste Programme for Europe.* Brussels.

Florin, N., Talwar, S., & Read, R. (2023). *Evaluating product stewardship benefits and effectiveness.* Sydney: Report prepared for the Department of Climate Change, Energy, Environment and Water.

Florin, N., Talwar, S., Read, R., Legg, R., Brydges, T., & Ruoso, I. (2023). *Environmental, social and economic benefits of product stewardship initiatives in Australia.* Sydney: Product Stewardship Centre of Excellence.

Hall, J. (2002). Sustainable development innovation: a research agenda for the next 10 years. *Journal of Cleaner Production*, 195-196.

Hirschhorn, J., Jackson, T., & Baas, L. (1993). Towards prevention - the emerging environmental management paradigm. In T. Jackson, *Clean production strategies - developing preventative environmetnal management in the industrial ecology* (pp. 125-142). New York: Lewis Publishers.

Lacy, P., & Rutquist, J. (2015). *Waste to wealth: the circular economy advantage.* London UK: Palgrave Macmillan.

Lowe, E. (2009, April 19). *China seeks to develop a circular economy*. Retrieved from Indigo Develoment: http://www.indigodev.com/Circular1.html

Meadows, D., Meadows, D., & Randers, J. (1992). *Beyond the limits.* White River Junctin, Vermont: Chelsea Green Publishing Company.

Ministry of Economy. (2008). *Towards a 3R-oriented Sustainable Society: Legislation and Trends.* Tokyo. Retrieved April 2024, from https://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/handbook2008_eng.pdf

Product Life Insitute. (2023, April)

Schall, J. (1992). *Does the Solid Waste management Hierarchy Make Sense? A Technical, Economic and Environmental Justification for the Priority of Source Reduction and Recycling.* Yale: Program on Solid Waste Recycling, Yale University.

Talwar, S., Lewis, H., & Retamal, M. (2022). *Circular economy metrics: a review.* Sydney: Circular Australia.

Tibbs, H. (1999). Sustainability. *Deeper News , 10*(1).

United Nations. (2024, April). *The 17 Goals*. Retrieved from Sustainable development: https://sdgs.un.org/goals

US Chamber of Commerce. (2015). *Achieving a Circular Economy: How the Private Sector is Reimagining the Future of Business.* Washington DC.

Vollenbroek, F. (2002). Sustainable development and the challenge of innovation. *Juornal of Cleaner Production*, 215-223.

Von Weizsacker, E., Lovins, A., & Lovins, L. (1997). *Factor four: doubling wealth, halving resource use.* Sydney: Allen & Unwin.

WCED. (1987). *Our common future.* Oxford: Oxford University Press.

APPENDIX

Examples of potential environmental, social and economic impacts and avoided impacts of waste management options

	Environmental impacts (-ve)	Avoided environmental impacts (+ve)	Social Impacts	Economic Impacts
Avoidance	Unlikely	Impacts at every stage of the product life cycle – materials, energy, emissions, wastes etc.	Need to change consumption habits and patterns	Some products / components may not need to be produced, with potential economic losses to manufacturers
Reduction	Unlikely	Impacts at every stage of the product life cycle – materials, energy, emissions, wastes	Cost saving to consumers	Cost saving to the manufacturer / supplier
Reuse	Transport – use of fuel, air emissions etc. Cleaning – water, detergents	Impacts of materials processing and product manufacture – materials, energy, emissions, wastes Avoided landfill impacts – air emissions, leachate, visual impact	Need to change consumption habits and patterns. Cost saving to consumers	New business opportunities to establish collection & refurbishment service
Remanufacturing	Transport – use of fuels, air emissions Manufacture of replacement parts – materials, energy, emissions, wastes Remanufacturing process - energy	Impacts of materials processing and product manufacture – materials, energy, emissions, wastes Avoided landfill impacts – air emissions, leachate, visual impact	Need to change waste disposal patterns, i.e. source separation but does not encourage re-thinking of consumption habits	New business opportunities in remanufacturing
Recycling	Transport – use of fuels, air emissions Reprocessing – energy,	Avoided impacts of manufacturing virgin materials - materials, energy, emissions, wastes Avoided landfill impacts – air emissions, leachate,	Need to change waste disposal patterns, i.e. source separation but does not encourage re-	New business opportunities in reprocessing

	water, chemicals, emissions, wastes (contamination, by-products)	visual impact	thinking of consumption habits	
Composting (organics)	Transport – use of fuels, air emissions Composting – energy, water, possibly odour	Avoided impacts of fertilizer and pesticide manufacture - materials, energy, emissions, wastes, water conservation and increased crop yield from use of compost as mulch; carbon sequestered in land	Need to change waste disposal patterns, i.e. source separation	New business opportunities in composting
Energy Recovery	Transport – use of fuels, air emissions Energy recovery process – energy, water, emissions, solid wastes (ash, grit, slag, scrubber residue)	Avoided impacts of energy production from other fuel sources – air emissions, wastewater, solid wastes (ash) Avoided landfill impacts – air emissions, leachate, visual impact	Possible community opposition to new facilities – perception of environmental impacts Does not encourage re-thinking of consumption habits	New business opportunities in energy recovery
Treatment / stabilisation	Transport – use of fuels, air emissions Treatment process – materials, energy, wastes, possibly odour	Avoided landfill impacts – air emissions, leachate, visual impact; potential energy credit if anaerobic digestion is used (biogas collection and energy generation)	Possible community opposition to new facilities – perception of environmental impacts Does not encourage re-thinking of consumption habits	New business opportunities in waste treatment
Disposal – landfill	Transport – use of fuels, air emissions Landfill impacts – air emissions, leachate, visual impact	Avoided impacts of energy production from other fuel sources – air emissions, wastewater, solid wastes (ash) due to gas recovery and energy generation; carbon sequestration	Community opposition to new landfills – visual/aesthetic impact	Low cost of disposal a disincentive to recovery and recycling

Product Stewardship Centre of Excellence | c/- Institute for Sustainable Futures | University of Technology
PO Box 123 | Broadway NSW 2007

www.stewardshipexcellence.com.au